GUJARAT TECHNOLOGICAL UNIVERSITY

MECHATRONICS ENGINEERING (20)
MEMS AND NANOTECHNOLOGY
SUBJECT CODE: 2182008
B.E. 8th SEMESTER

Type of Course: Engineering Science

Prerequisite: NA

Rationale: The subject is used for understanding the concepts and techniques related to design and manufacturing of MEMS components. It will be useful to attain a broad range of the knowledge required to flourish in the rapidly developing field of Nanotechnology.

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Course content	Total Hrs.	Percentage
1.	**Introduction to MEMS and Micro Systems:** MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Microfabrication, Microsystems and Microelectronics, The Multidisciplinary Nature of Microsystem, Design and Manufacture, Microsystems and Miniaturization, Applications of Microsystems in the Automotive Industry, Applications of Microsystems in Other Industries	07	18
2.	**Working Principles of Microsystems:** Introduction, Microsensors, Microactuation, MEMS with Microactuators, Micro accelerometers	03	07
3.	**Engineering Mechanics for Microsystem Design :** Introduction, Static bending of thin plates, Mechanical Vibration, Thermo mechanics, Fracture mechanics, Thin Film mechanics, Use of FEA in MEMS structures.	05	12
4.	**Scaling Laws in Miniaturization :** Introduction to Scaling, Scaling in Geometry, Scaling in Rigid-Body Dynamics, The Trimmer Force Scaling Vector, Scaling in Electrostatic Forces, Scaling in Electromagnetic Forces, Scaling in Electricity, Scaling in Fluid Mechanics	02	05
5.	**Microsystem Materials:** Molecular Theory and Intermolecular Forces – Silicon Piezo Resistors– Electrochemistry – Substrates and Wafers – Silicon Compounds – Polymers – Packaging Materials.	05	12
6.	**Microsystem Fabrication Process:** Photolithography – Ion Implantation – Diffusion –Oxidation – Chemical Vapor Deposition – Etching – Applications of MEMS in Automatic-Telecom and Other Industries.	09	22

7.	**Nanotechnology Basics:** Nanobuilding Blocks – Atoms and Molecular Structure –Molecular Recognition – Tools For Measuring Nanostructures – Electron Microscopy – Spectroscopy – Molecular Synthesis and Polymerization – Encapsulation.	03	07
8.	**Science of Nano Materials** Classification of nano structures – effect of the nanometer length scale effects of nano scale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties – effect of nanoscale dimensions on biological systems. Fabrication methods – Top down processes – bottom up process.	04	10
9.	**Applications of Nanotechnology In Medicines:** Nanobiosensors – Electronic Nose – Photo Dynamic Therapy – Molecular Motors – Protein Engineering.	03	07

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**30**	**15**	**15**	**10**	**-**

Legends: R : Remembrance ; U = Understanding; A = Application and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

Reference Books:

1. Tai,Ran Hsu, "MEMS & Microsystems Design & Manufacture", Tata Mc Graw Hill,2002
2. Richard Booker, Earl Boysen, "Nanotechnology", Wiley Dreamtech (p) Ltd, 2006
3. Mart Ratner, Daniel Ratner, "Nanotechnology", Pearson Education, 2003
4. Charles P. Poole. "Introduction to nanotechnology," Wiley publications,2003
5. Norio Taniguchi, Nano Technology, Oxford University Press, New York, 2003
6. The MEMS Hand book, Mohamed Gad-el-Hak, CRC Press, New York, London

Course Outcomes (COs):

After learning the course the students should be able to:

1. To attain a broad range of the knowledge required to flourish in the rapidly developing field of MEMS and Nanotechnology.
2. Facilitate the application of basic physical laws, chemical laws, dynamic behaviour as well as steady state performance to design and synthesize MEMS and Microsystems.
3. Acquaint him / her with applications of mems fabrication techniques and nanotechnology to solve the problems encountered at a macro level.
4. Gain Proficiency in modeling, simulating and evaluating MEMS and Microsystems.

List of Experiments:

1. Introduction to MEMS & Microsystems.
2. Mechanics of MEMS.
3. Dynamics of MEMS.
4. Fabrications processes for MEMS.
5. To Perform Multiphysics Analysis of a Thermal Actuator -I.
6. To Perform Multiphysics Analysis of a Thermal Actuator -II.
7. Design and Analysis of MEMS Pressure Sensor-I
8. Design and Analysis of MEMS Pressure Sensor-II
9. MEMS simulations using COMSOL
10. Nanotechnology basics

Design based Problems (DP)/Open Ended Problem:
Student may be given a task to simulate MEMS structures using softwares.

Major Equipment:
MEMS simulation software may be used for the performance of simulation.

List of Open Source Software/learning website:

The website of NPTL may be utilized for additional learning.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.